

Case Study 1: An Evidence-Based Practice Review Report

*Theme: Interventions to improve social or emotional development, or mental health
and wellbeing*

*How effective are biofeedback games in reducing anxiety symptoms in school
aged children?*

Summary

The development and expansion of technology as a means to support the mental health of children and young people presents a variety of opportunities to supplement and adapt traditional forms of therapeutic interventions such as cognitive behavioural therapy (CBT).

An emerging area of intervention development involves applying therapeutic principles such as relaxation techniques within engaging technologies such as video games. The potential benefits of such intervention lie in user motivation and accessibility, however the efficacy of such technological interventions in addressing the mental health needs of children and young people remains unclear in this newly emerging field. This systematic literature review aims to examine how effective one particular type of video game-based intervention, biofeedback games, is on reducing the anxiety symptoms of school aged

combined sample size of 128 participants and four specific biofeedback games employed, applying three separate biofeedback techniques

need in this area, as well as the variety of mental health intervention format and delivery, the need for interventions developed and evaluated from established bases of evidence is crucial (Creswell et al. 2020).

One approach to supporting anxiety in children and young people that has been widely studied and applied is that of cognitive behavioural therapy or CBT (Podina

The rapid development and availability of technology globally within recent years has presented a variety of emerging opportunities for the support and enrichment of child learning, health and wellbeing. One area in particular that has received attention is that of the development of video games with a specific purpose to enhance areas of child and adolescent functioning (Zhonggen, 2019). Such video games are commonly termed virtual exposure therapy for children with specific phobias (Whiteside et al. 2020), to improve social skills in children with developmental conditions characterised by social impairment such as autism (Noor et al. 2012), and as a tool to support traditional forms of psychotherapy for young people (Brezinka & Hovestadt, 2007).

Biofeedback

The term biofeedback refers to a method of technology that measures the physiological responses of an individual, for example heart rate or skin conductivity, and feeds this information back to the individual in such a way that they are able to monitor this response and utilise the information constructively to inform their health and wellbeing (Gilbert & Moss, 2003).

Rationale for Review

While the use of biofeedback as a therapeutic intervention for child mental health has been examined within previous studies (Thabrew et al. 2018), there is less research into the use of biofeedback technology applied within a video game intervention for mental health generally in children and young people. Furthermore, the efficacy of its use within

Review Question

How effective are biofeedback games at reducing the anxiety symptoms of school aged children?

Critical Review of Evidence Base

Literature Search

A search of the databases PsycInfo, Pubmed, Medline, ERIC (EBSCO) and Web of Science was conducted following a scoping review of the literature conducted through Google Scholar. Table 1 displays the search terms used and rationale behind their inclusion, while a visual depiction of the full literature search is displayed in Figure 1 in flowchart format.



Figure 1: Flowchart of Literature Search

Table 2

Inclusion and Exclusion Criteria

	Inclusion Criteria	Exclusion Criteria	Rationale
1.) Type of publication	Peer reviewed journal	Articles not published in peer reviewed journals Conference articles Dissertations	Research subjected to scrutiny indicates a standard of quality and legitimacy desirable for review.

2.) Type of Intervention	Biofeedback video game	Video game intervention with no biofeedback element
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2. Knox, M., Lentini, J., Cummings, T. S., McGrady, A., Whearty, K., & Sancrant, L. (2011). Game-based biofeedback for paediatric anxiety and depression. *Mental Health in Family Medicine*, 8(3), 195.
 3. Scholten, H., Malmberg, M., Lobel, A., Engels, R. C., & Granic, I. (2016). A randomized controlled trial to test the effectiveness of an immersive 3D video game for anxiety prevention among adolescents. *PloS one*, 11(1), e0147763.
 4. Schuurmans, A. A., Nijhof, K. S., Engels, R. C., & Granic, I. (2018). Using a videogame intervention to reduce anxiety and externalizing problems among youths in residential care: an initial randomized controlled trial. *Journal of Psychopathology and Behavioral Assessment*, 40(2), 344-354.
 5. Schuurmans, A. A., Nijhof, K. S., Vermaes, I. P., Engels, R. C., & Granic, I. (2015). A _____ and anxiety problems. *Games for Health Journal*, 4(5), 401-408.
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Mapping the Field

As outlined above, a systematic search and screening of relevant online databases identified five studies for inclusion within the scope of this review. Each of the included studies implemented and examined at least one biofeedback game for a sample of school-age participants and assessed the impact of the intervention on anxiety symptoms. A summary of the key characteristics of the included studies is provided in Appendix B.

Weight of Evidence

The five included studies

did not report the specifics of this analysis. This lack of transparency makes it unclear whether individuals with ID may have accessed the intervention in ways that led to differences in observed outcomes.

Similarly, Schuurmans et al. (2015) included participants with both clinical levels of anxiety and externalising behaviour in the form of hyperactivity, conduct problems and issues with peers. There was a lack of focus solely on anxiety symptoms within this study, alongside a lack of clarity on the definition, frequency of occurrence and causal mechanisms behind the identified externalising behaviours of the eight participants involved in the small-n design employed by the authors. This resulted in difficulty interpreting the reported high compliance with the study and reduction in both anxiety and engagement with the intervention was unclear. Furthermore, there is little to support the generalisation of these results to wider populations, as well as a lack of clarity as to the adaptations to the intervention that may have been needed to fit the needs of participants with varying co-morbid difficulties. These limitations are reflected in the low WoE A ratings for this study.

Setting

Of the five studies included, four were conducted within the Netherlands (Bossenbroek et al. 2020; Scholten et al. 2016; Schuurmans et al. 2015; Schuurmans et al. 2018) and one within the USA (Knox et al. 2011). While no studies conducted within the UK were identified within the inclusion criteria of the review, all five were situated within country members of the Organisation for Economic Co-operation and Development (OECD), indicating shared economic and social infrastructures likely to generalise to a reasonable

The focus of the review was

dimension. Similarly reflected in these ratings, a shared strength between the studies was the use of biofeedback games designed with the purpose of improving anxiety in children and young people, rather than developed for general use or an alternative SEMH need such as social skills training.

Outcomes and Effect Sizes

Effect sizes for anxiety outcome measures employed by the included studies were obtained in order to compare findings that were relevant to the review question. To

Table 5

Study Author and Year	Total Sample Size	Outcome Measure	Intervention Condition			Control Condition			P	Effect size (d)	Descriptor	WoE D
			N	Pre-Mean (SD)	Post Mean (SD)	Follow-Up Mean (SD)	N	Pre-Mean (SD)				
Scholten et al. (2016)	138	Spence Scale Self Report (SCAS; Dutch language version): Total Anxiety Score	70	0.83 (0.33)	0.74 (0.33)	0.72 (0.30)	68	0.86 (0.31)				

Study Author and Year	Total Sample Size	Outcome Measure	Intervention Condition			Control Condition			Outcome	P	Effect size (d)	Descriptor	WoE D
			N	Pre-Mean (SD)	Post Mean (SD)	Follow-Up Mean (SD)	N	Pre-Mean (SD)					

Table 6
Effect Sizes of Small N Studies

Study Author and Year	Sample Size	Measure (Anxiety)	Within Subjects Comparison			Outcome	P	Effect Size	Descriptor	WoE D Rating
			Baseline Mean Score/ A0 Phase (Standard Deviation)	Intervention Condition Mean Score/ B Phase	Post-Intervention Mean Score/ A1 Phase (Standard Deviation)					
Bossenbroek et al. (2020)	8	State-Trait Anxiety Inventory (STAI; Dutch language version)	3.33 (1.41)	2.40 (1.26)	2.53 (1.01)	Reduction in anxiety symptoms of participants in intervention and post-conditions compared to baseline	N/A	-0.29	Small	Moderate
Schuurmans et al. (2015)	8	Spence Anxiety Scale (SCAS; Dutch language version), self-report	23.25 (19.59)	N/A	16.38 (14.12)	Reduction in anxiety symptoms of participants in intervention and post-conditions compared to baseline	N/A	-0.40	Small	Moderate

Findings

While all five studies reviewed reported a decrease in anxiety symptoms of participants who had engaged with the biofeedback-based video game interventions employed, there was a variation in the pattern of these results.

Knox et al. (2011), employing an experimental between subject design, reported significant reduction in anxiety symptoms for their intervention group compared to a waitlisted control group as measured by two widely used, validated self-report child measures of anxiety. Large effect sizes were obtained for these results, although the study authors note the limitations in terms of their sample sizes of 12 participants per group, restricting the generalisation of these positive findings. It could also be considered that, of the five studies reviewed, Knox et al. (2011) was unique in deploying two biofeedback videogames, both of which were developed by researchers independent to

findings could be that

two more established biofeedback videogames that were used as anxiety interventions, of which the researchers were less personally familiar with when compared to the authors of the other four reviewed studies. It could be that their lack of personal bias allowed for more objective instruction to participants, which may have facilitated engagement.

Another explanation could lie in the variation of games offered, which may have engaged participant attention more effectively. Further research with independent researchers evaluating all discussed games would allow insight into these hypotheses.

Schuurmans et al. (2018) similarly reported a significant decrease in anxiety symptoms in an intervention group compared to a control group that received treatment as usual for anxiety. Although sample sizes were also limited for this study, and effect sizes for results were small, the use of randomisation and data collection from both participant and

caregiver were strong methodological qualities that lend support to the evidence produced in favour of the use of biofeedback videogames to address anxiety in young people. By comparison, Schuurmans et al. (2015) indicated significant reductions in anxiety symptoms as reported by both caregiver and self-report measures after intervention, with moderate and large effect sizes respectively, but did not utilise a control group or multiple baseline measures as discussed previously. The results of this study should therefore be interpreted with caution as their generalisability cannot be assumed. Bossenbroek et al. (2020), however, did employ a multiple baseline design and found a significant decrease in anxiety symptoms in participants in post-intervention phases. Although a small effect size was obtained, the authors chosen setting of a residential specialist school presented obstacles such as scheduling unpredictability and high levels of participant need that may have impacted consistency of delivery of the intervention. Interestingly, Scholten et al. (2016) indicated a significant decrease in self-reported anxiety symptoms within both the intervention and control group of their study, although there was no significant difference in this decrease between the two groups. As this study deployed an alternative video game for use within the control group that did not involve a therapeutic element, or a biofeedback component, it was speculated by the authors that the act of playing a videogame alone may be enough to alleviate symptoms of anxiety in young people. Although effect sizes were mostly small for these results, the methodological quality of this study was reflected in its high WoE D rating. As such, while the study may not have provided evidence to suggest that videogames involving a biofeedback element present better potential for anxiety intervention than those without, the authors have nonetheless provided support for the use of videogames generally to significantly decrease anxiety, and include the use of biofeedback games within this finding.

Conclusion and Recommendations

Discussion

The aim of this review was to examine the evidence-base in support of the use of biofeedback games to reduce anxiety symptoms in school aged children, and in doing so to consider the research question of whether such games can be considered effective interventions for this population. Key findings extracted from the available research in this area include the limited research currently available within this area; the initial online database search conducted within the review process returned fewer than 100 studies to consider for inclusion. Furthermore, of the studies included for review it can be observed that there is significant variation in the type of biofeedback game evaluated, the characteristics of participants recruited, the research designs employed and the settings in which the intervention was delivered.

Limitations

Generalisability

A significant limitation to the evidence reviewed within this review lies in the difficulties generalising findings. Four out of the five studies reviewed were conducted by researchers working within the Behavioural Science Institute (BSI) of Radboud University in the Netherlands, with one researcher, I. Granic, appearing as a co-author on three papers and another, A. A. Schuurmans, on two (Bossenbroek et al. 2020; Scholten et al. 2016; Schuurmans et al. 2015; Schuurmans et al. 2018). The biofeedback games involved in this research were developed as part of projects conducted within Radboud

investigate the efficacy of video games and related technology in supporting the mental health of children and young people (Radboud University, BSI, 2021).

While the fact that the majority of the studies included for review were conducted within the same setting and research team should not be considered such a significant limitation as to disregard any potential benefits of the biofeedback games studied or positive findings produced by the authors, caution should be taken in interpreting such findings as robust evidence in favour of the use of such games as anxiety interventions. Careful scrutiny should be applied to any conclusions taken from the moderate to high weightings

necessarily allow for research weaknesses such as the potential for experimenter bias to be identified. Independent evaluation by researchers unaffiliated with the development of games such as DEEP and Dojo would be necessary in order to support the findings produced by the GEMH team regarding the benefits of applying biofeedback, game

interventions, it remains uncertain as to whether this technology could realistically be implemented widely.

Specificity

Furthermore, the associations found in such research between additional factors such as socioeconomic status, ethnicity, gender and the experience of anxiety in children and adolescents raises further limitations present in the use of biofeedback games as intervention. As it stands, the current research has not fully investigated the influence of such factors on the use of this technology to reduce anxiety symptoms.

For example, survey research has shown that mental health disorders in children aged between 5 and 15 years of age are more prevalent in boys than girls (Sadler et al. 2018), although in terms of anxiety extensive research has suggested that girls experience a higher level of symptoms (Bosquet & Egeland, 2006). There is also extensive research examining gender differences in the use of video games in children and adolescents that not only suggests boys are more likely to play and enjoy online, console and computer gaming (Barnett et al. 1997), but that there are specific differences in the type of video games that children and young people of different ages prefer and are motivated to play (Greenber et al.

playing video games show greater performance on spatial learning and rotation tasks than those who do not play games, a finding which extends to female adults and children (Castell et al. 2019; Subrahmanyam & Greenfield, 2004).

Implications for Educational Psychology Practice

As an intervention to address mental health in children and adolescents, biofeedback games represent an emerging area of technological development. The use of such games to reduce anxiety symptoms by supporting and teaching relaxation techniques with a strong basis in cognitive behavioural therapy principles has been shown to have potential benefits, however the analysis conducted within the current review has evidenced that studies with robust, objectively high methodological quality have so far found no strong effects in favour of this type of intervention for anxiety. The results of the review suggest that educational psychologists should therefore be cautious in recommending the use of this technology to schools.

Furthermore, the technology required for the use of biofeedback games, both in terms of software and technical equipment such as sensors and bespoke hardware, can be costly and of use to only one specific type of game. The targeted nature of this type of intervention means that schools will not necessarily be able to make use of purchased equipment with large populations of students, a significant consideration when the high numbers of children evidenced to experience anxiety related conditions is taken into account. Returning to the example previously highlighted of the current focus on the role schools have in supporting the mental health of young people through government initiatives such as those proposed within the 2017 Green Paper (DHSC; DfE), there is increasing pressure on schools to provide a broad range of provisions across multiple levels of student need. Critique of this governmental pressure highlights the need for a systemic, collaborative approach to mental health support between schools, NHS services and social care which recognises the strain that costly, targeted interventions

such as, potentially, could be represented by biofeedback games, may have upon under-resourced schools (England & Mughal, 2019). Evidence from teacher interviews has suggested, for example, that training on mental health issues is a key element that education staff feel should be addressed as a foundation before the implementation of targeted interventions (Shelemy et al. 2019).

Educational psychologists should therefore address and research the individual provisions and existing resources within schools before considering the application of technology assisted interventions such as biofeedback games.

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schools: what do teachers want and need?. *Emotional and Behavioural Difficulties*, *24*(1), 100-116.

Zhonggen, Y. (2019). A meta-analysis of use of serious games in education over a decade. *International Journal of Computer Games Technology*, 2019.

Appendix A

A.1

Table 7

Articles Excluded at Full Text Screening

Reference	Reason for Exclusion
Burkhart, K., Mason, E., & Lazebnik, R. (2018). Stress management intervention: A pilot evaluation in an urban adolescent medicine clinic. <i>Clinical Pediatrics</i> , 57(6), 700-705.	3.) No outcome measure of anxiety
Carlier, S., Van der Paelt, S., Ongenae, F., De Backere, F., & De Turck, F. (2020). Empowering children with ASD and their parents: Design of a serious game for	

- Maricic, A., Leang, H. P., Lazareva, O., & Bazanova, O. (2005, June). New biofeedback games. In *27th International Conference on Information Technology Interfaces, 2005*. (pp. 263-268). IEEE. 1.) Conference paper
- Maricic, A., Leang, H., Lazareva, O., & Campbell, J. (2004, June). Cloning biofeedback games. In *Proceedings. Elmar-2004. 46th International Symposium on Electronics in Marine* (pp. 406-411). IEEE. 1.) Conference paper
- Reineke, A., Sowder, E., & Gevirtz, R. (2007, May). Effects of an inter-active biofeedback game on anxiety and pain in children with cancer. In *BIOLOGICAL PSYCHOLOGY* (Vol. 75, No. 2, pp. 213-214). PO BOX 211, 1000 AE AMSTERDAM, NETHERLANDS: ELSEVIER SCIENCE BV. 1.) Conference paper
- Sonne, T., & Jensen, M. M. (2016, February). Chillfish: A respiration game for children with ADHD. In *Proceedings of the TEI'16: Tenth International Conference on Tangible, Embedded, and Embodied Interaction* (pp. 271-278). 1.) Conference paper
- Thabrew, H., Stasiak, K., Hetrick, S. E., Wong, S., Huss, J. H., & Merry, S. N. (2018). E Health interventions for anxiety and depression in children and adolescents with long term physical conditions. *Cochrane Database of Systematic Reviews*, (8).

Author and Country	Sample	Setting	Study Design			Measures		Game	Type of Biofeedback	Technology
			Type of Study	Sessions	Follow Up	Anxiety	Other			
Schuurmans et al. (2015) Netherlands	N=8 with and without intellectual disability (ID) with clinical levels of anxiety Mean age =14.38 years F=3									

Appendix C

C.1 Weight of Evidence A: Methodological Quality

To assess for methodological quality of the studies included within the review, two separate coding protocols were used. For the three studies involving experimental, group designs (Knox et al. 2011; Scholten et al. 2016; Schuurmans et al. 2018) Gersten et

protocol, as detailed in Table 10 below:

Table 10

Gersten et al (2005) Rating Criteria for WoE A

WoE A Rating	Criteria based upon Gersten et al. (2005)
3 (High)	At least 9 essential criteria are met by study At least 5 desirable criteria are met by study
2 (Moderate)	At least 9 essential criteria are met by study Between 1 and 4 desirable criteria are met by study
1 (Low)	

C.2 Weight of Evidence B: Methodological Relevance

To assess for the methodological relevance of the included studies to the review question of whether biofeedback game-based interventions are effective in reducing anxiety symptoms in children and adolescents, a set of criteria was developed and implemented involving two dimensions. Based upon a framework concepts. B

$$\text{WoE B score} = \frac{\text{Study Design Rating} + \text{Outcome Measure Rating}}{2}$$

Final WoE B Scores were assigned the following ratings:

Table 14

WoE B Weightings

WoE B Score	WoE B Final Weighting
2.1 to 3	3 (High)
1.5 to 2.0	2 (Moderate)
1.4 or below	1 (Low)

C.2 Weight of Evidence C: Topic Relevance

To assess whether the focus of the included studies was relevant to the current review, five domains were developed and relevant criteria applied. It was considered that the profile of difficulties experienced by participants, including and relating to anxiety levels,

biofeedback employed, the type of video game utilised within interventions and the study setting were significant. WoE C criteria and dimensions are given in Table 15, with WoE C scores for included studies given in Table 16. Final WoE C scores were given as the average across each of the five dimensions displayed.

Table 15

Rating Criteria for WoE C

WoE C Dimension	Rating	Rationale
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Yes waitlist condition was described as treatment as usual and offered biofeedback after study completion

No

Unknown/unable to code

Essential Quality Indicators for Outcome Measures

1. Were multiple measures used to provide an appropriate balance between measures closely aligned with the intervention and measures of generalised performance?

Yes MASC, CDI, STAIC

No

Unknown/unable to code

measured at the appropriate times?

Yes pre and post intervention

No

Unknown/unable to code

Essential Quality Indicators for Data Analysis

1. Were the data analysis techniques appropriately linked to key research questions and hypotheses? Were they appropriately linked to the unit of analysis in the study?

Yes

No

Unknown/unable to code

2. Did the research report include not only inferential statistics but also effect size calculations?

Yes

No

Unknown/unable to code

Desirable

Yes

No

Unknown/unable to code

2. Did the study provide not only internal consistency reliability but also test-retest

Unknown/unable to code

7. Did the research report include actual audio or videotape excerpts that capture the nature of the intervention?

Yes

No

Unknown/unable to code

8. Were results presented in a clear, coherent fashion?

Yes

No

Unknown/unable to code

Coding Protocol: Horner et al. (2005). The Use of Single-Subject Research to Identify Evidence Based Practice in Special Education

Name of Coder: X

Date: 20.01.21

Full Study Reference: Bossenbroek, R., Wols, A., Weerdmeester, J., Lichtwarck-Aschoff, A., Granic, I., & van Rooij, M. M. (2020). Efficacy of a virtual reality biofeedback game (DEEP) to reduce anxiety and disruptive classroom behavior: Single-case study. *JMIR mental health*, 7(3), e16066.

Intervention Description: DEEP VR game using respiratory biofeedback to measure

Unknown/unable to code

2. The process for selecting participants is described with operational precision

Yes

4. Dependent variables are measured repeatedly over time.

Yes

No

Unknown/unable to code

5. Data are collected on the reliability or inter-observer agreement associated with each dependent variable, and IOA levels meet minimal standards.

Yes

No

Unknown/unable to code

Individual Quality Rating:

3: All criteria met

2: Three to four criteria met

1: One to two criteria met

0: No criteria met

Independent Variable

1. Independent variable is described with replicable precision.

Yes

No

Unknown/unable to code

2. Independent variable is systematically manipulated and under the control of the experimenter.

Yes

No

Unknown/unable to code

Individual Quality Rating:

3: All criteria met

2: Two criteria met

1: One criteria met

0: No criteria met

Baseline

1. The majority of single-subject research studies will include a baseline phase that provides repeated measurement of a dependent variable and establishes a pattern of responding that can be used to predict the pattern of future performance, if introduction or manipulation of the independent variable did not occur.

Yes

No

Unknown/unable to determine

2. Baseline data

Unknown/unable to code

3. The results document a pattern that demonstrates experimental control.

Yes

No

Unknown/unable to code

Individual Quality Rating:

3: All criteria met

2: Two criteria met

1: One criteria met

0: No criteria met

External Validity

1. Experimental effects are replicated across participants, settings, or materials to establish external validity.

Yes

No

Unknown/unable to code

Individual Quality Rating:

3: Experimental effects are replicated across more than half of all participants and a specific setting

2: Experimental effects are replicated across a quarter of all participants

1: Experimental effects are replicated across at least one participant

0: No evidence of experimental effect replication

Social Validity

1. The dependent variable is socially important.

Yes

No

Unknown/unable to code

2. The magnitude of change in the dependent variable resulting from the intervention is socially important.

Yes

No

Unknown/unable to code